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**UNITED STATES PATENT AND TRADEMARK OFFICE**

Examiner: Rina I. Duda

Art Unit: 2837

In re:

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**JAN 19 2003**  
**T.C. 2800**

Applicant: Martin KESSLER

Serial No.: 09/915,426

Filed: July 26, 2001

**AMENDMENT**

November 14, 2002

Hon. Commissioner of  
Patents and Trademarks  
Washington, D.C. 20231

Sir:

Responsive to the Office Action of August 14, 2002, please  
amend the application as follows:

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In the specification:

Page 2, last paragraph, amend as follows:

Brushless direct current motors as a rule are provided with several phases, in which the corresponding induced counter voltages can be utilized for position determination of the actual rotary position of the rotor of the electric motor. For this purpose a demultiplexer is utilized, with which the phase which is to be selected with respect to its induced counter voltage, is selected. By means of a [comparator] comparator, its corresponding zero crossing is subsequently detected.

Page 3, first paragraph, amend as follows:

In order to match the corresponding induced countervoltage of the selected phase to the input direct phase region of the [comparator] comparator, a voltage divider is utilized. Each used voltage divider has the same division ratio. In addition to the use of voltage dividers with identical division ratios, it has been found that it is possible to replace the demultiplexers with bipolar transistors in the series branch. By means of a corresponding series pass transistor, the corresponding selective phase is

connected with the [comparator] comparator. Since at the series pass transistors of each phase a no more negligible voltage drops, for compensation at the reference branch at the bipolar transistors provided there also a voltage drop is produced. The disadvantage of this solution is the condition that the component element tolerances and temperature influences can drive the produced voltage drop so far from one another that the phase displacement which results from it can have influence on the power and the efficiency of the brushless direct current motors.

Please amend the paragraph bridging pages 3 and 4 as follows:

Moreover, the solution with the use of series pass transistors in the series branches has the disadvantage that the series pass transistors provided there have parasitic capacities. In the case of a cycled control of the end stage transistors, also the corresponding blocked transistor, through this capacities voltage peaks are coupled from the phase to the [comparator] comparator input. Thereby the interference voltage difference at the [comparator] comparator is significantly reduced, and at low rotary speeds of the brushless direct current motor the induced countervoltage goes down

into the interference spectrum and no evaluation of the input voltage signals at the [comparator] comparator is possible.

Page 4, first complete paragraph, amend as follows:

Instead of bipolar transistors which can be incorporated both in the reference branch and also in each phase, also MOS field effect transistors can be utilized. With the use of the field effect transistors, for the purpose of selecting the corresponding phase to be evaluated, the voltage drop through the field effect transistor can be negligible. This however is connected with the disadvantage that the field effect transistors when compared with the effect of bipolar transistors have substantially greater parasitic capacities. The greater the parasitic capacities, the lower the interference voltage difference at the input size of the [comparator] comparator. Thereby with the use of the field effect transistors in the evaluating circuit, no rotary speeds of the brushes direct current motors are no longer detected in the occurring interference spectrum, and thereby the problems which are contributed to the use of bipolar transistors in this connection are amplified.

Please amend the paragraph bridging pages 4 and 5 as follows:

A further solution for determination of the actual position of the rotor for a sensorless, brushless direct current motors is to implement in the phases to be selected an OR-logic with diodes. Transistors which are connected through diodes blend all not selected phases, so that one phase can be placed at the input side of the [comparator] comparator. Thereby the skipping of voltage peaks of one phase via parasitic capacities is minimized, as can occur with the use of bipolar transistors or also field effect transistors in the remaining variants. The disadvantage of the use of diodes is the condition that the voltage drops in the corresponding longitudinal paths to be evaluated can be higher than the respective voltage drop or the spaced voltage drops via component tolerances and temperature than with the use of bipolar transistors in the evaluating circuit.

Please amend the paragraph bridging pages 6 and 7 as follows:

In accordance with the present invention the combination of demultiplexers and the multiplexers and [comparitors] comparators, in addition to the provided edge conditions of the costs and place minimization

can cover the following requirements. Each phase to be evaluated in a brushless direct current motor is provided with resistors for securing against voltage peaks on the one hand, on the other hand in each phase to be evaluated in the brushless direct current motor a transistor element is received. By means of the transistor elements which can be formed as [a] bipolar transistors or [a] field effect [transistor] transistors, it is possible for the not selected time, or in other words during the time period in which the corresponding phase is not directly evaluated from position recognition of the position of the rotor, voltage peaks can be removed [so] in such a way that in each phase the [transistor] transistors are is connected to a reference potential. Thereby it is guaranteed that the occurring voltage peaks or interferences in the directly not evaluated phases pass in the moment into the phase used in the evaluation and affect the evaluation results.

Page 7, first paragraph, amend as follows:

Each phase of a brushless direct current motor is provided with a [comparator] comparator component. The OR-connection is performed first after the comparison of the corresponding phase voltage with the comparison voltage. Thereby in advantageous manner components in the series path are dispensed with, so that in the series path no voltage drop is

produced. This also provides the advantage that also a voltage drop in the reference branch used for the comparison can be dispensed. This allows a substantially most cost favorable design of the evaluation circuit.

Page 9, first paragraph, amend as follows:

Figure 1 is a view showing a principle diagram for a sensorless position determination with induced countervoltages of a corresponding voltage divider, which together are connected to an input of a [comparator] comparator element;

Page 9, second paragraph, amend as follows:

Figure 2 is a view showing a demultiplex circuit with series pass transistors arranged in the corresponding phases to be evaluated, and also connected together to the input of the [comparator] comparator element;

Page 3, third paragraph, amend as follows:

Figure 3 is a view showing a demultiplexer with diodes arranged in a reference branch as well as in the corresponding phase

strands to be evaluated, which are connected together to the input of the [comparator] comparator component; and

Page 4, fourth paragraph, amend as follows:

Figure 4 is a view showing a demultiplexer with a reference branch and four phases to be evaluated as an example, wherein each phase to be evaluated is associated with a separate [comparator] comparator component.

Page 10, first paragraph, amend as follows:

Figure 1 shows a demultiplexer/[comparator] comparator combination. It is set at each phase to be evaluated in a brushless direct current motor. Reference numeral 1 identifies the polarity of a voltage source. Inductivities 2 are provided with each phase to be evaluated, for example in a brushless direct current motor. They induce alternating counter voltages 3. The zero or zero crossover of the alternating voltages 3 allows for position determination to evaluate the position of the rotor in a brushless, sensorless direct current motor. As can be seen from Figure 1, the resistors 4, 5, 6, 7 each with the resistor 8 form a first voltage divider 9, and the



resistor 10 with the resistor 11 represent a second voltage divider 12. The both voltage dividers 9 and 12 have the same divider ratio, to adapt the induced counter voltages 3 in the phases of the sensorless, brushless current motor to be evaluated to the input direct cycle region of the [capacitor] comparator component 14. Reference numeral 15 at the [comparator] comparator component 14 identifies the corresponding control voltage pulses to be applied, while reference numeral 13 identify the input side with the input 1 and 2 of the [comparator] comparator component 14. At the output voltage  $U_A$  is taken at the output side of the [comparator] comparator element 14 as shown in Figure 1.

Please amend the paragraph bridging pages 11 and 12 as follows:

Reference numeral 1 again identifies the voltage source. In Figure [1] 2 one phase to be evaluated is illustrated completely, while the other phases to be evaluated are shown only schematically. Also, in this configuration from the prior art, all phases are connected to a [comparator] comparator component 14 which is common for all phases. The output voltage  $U_A$  can be taken at its output side as identified with reference numeral 16. Each phase to be evaluated is connected by a series pass

transistor 17 selectively and with the input side 13 of the [comparator] comparator component 14. A not negligible voltage drops in each corresponding phase branch at the series pass transistor 17, so that a voltage drop is produced for its compensation in the reference branch 18 by a series pass transistor component provided in it. The solution shown in Figure 2 has a disadvantage that a component tolerances and temperature influences can drive the produced voltage drop in each branch to be evaluated as well as in the reference branch so far from one another, that the phase displacement resulting from it can have a significant influence on the power and the efficiency on the brushless, sensorless direct current motor. Furthermore, the parasitic capacities of the transistors 17 are not too negligible. In the case of a cycled control of end stage transistors 19 (see Figure 1), with blocked transistor components 17 or 19, through these capacities voltage peaks from the phase can reach the input side 13 of the [comparator] comparator component 13. The produced effect is a reduction of the interference voltage difference. Thereby with small rotary speeds the induced counter voltages 3 go into an interference spectrum and an accurate position determination at the rotor of the brushless, sensorless direct current machine is no longer possible.

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Please amend the paragraph bridging pages 12 and 13 as follows:

In this arrangement also from the prior art all diodes and the phase branches to be evaluated are connected together to input side of a [comparator] comparator component 14. At the output side, the output voltage  $16 U_A$  can be taken at the [comparator] comparator component 14. Diode elements 22 are integrated both in the reference branch 21 and also in phase branches to be evaluated. Moreover, the individual phase branches of the demultiplexer arrangement in accordance with the embodiment of Figure 3 are connected with  $Z_A$  diodes, so that a protective circuit for over voltage limit is provided. In this configuration the produced voltage drops in the series branches are significant. The influences of component tolerances and temperature effects are stronger than in the solution shown in Figure 2 in which the transistor components 17 are integrated in the corresponding phase branches to be evaluated.

Please amend the first complete paragraph on page 13 as follows:

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Figure 4 shows the configuration proposed in accordance with the present invention. Reference numeral 1 identifies the voltage source whose voltage is supplied to a fully illustrated phase branch 23 of a brushless, sensorless direct current motor. The other phase branches 23 shown here in the example 4 are illustrated only schematically. Alternating voltages 3 are induced by inductivities which are provided in the phase branches 23. Their zero crossings are detected with the inventive device for position determination of the rotor of a direct current motor. In the reference branch 24 two resistors 6 and 7 are integrated, and voltage which acts in the reference branch is applied at the input side of each input of a [comparator] comparator component 14. The demultiplexer arrangement shown in Figure 4 is different from those in Figures 1, 2 and 3 in that, a separate [comparator] comparator component 14 is associated with each phase branch 23 to be evaluated in a sensorless, brushless direct current motor. The outputs of the inventive four independent [comparator] comparator components 14 are connected together to an output 16, at which the output voltage can be taken.

Please amend the paragraph on page 14 as follows:

Each phase 23 of a direct current motor to be evaluated contains its own independent [comparator] comparator component 14, at which control voltage inputs are provided and identified with reference numeral 15. Reference numeral 13 identifies the input side of the [comparator] comparator component 14. The OR-operation of the voltage values is performed after the comparison of the voltage in the individual phases 23 to be evaluated with the comparison voltage which acts in the reference branch 24. Thereby in an advantageous manner, components in the series branch of the multiplexer are dispensed with, and therefore no additional voltage drops are produced. Since each of the phases 23 to be evaluated contains a transistor component 17, a series transistor, or a bipolar transistor which connects then the non-selected time connects the [comparator] comparator input to the reference potential, the voltage peaks and other interferences do not reach the input side 13 of the component 14 provided in each phase branch 23 to be evaluated. With this solution a very high interference voltage difference is guaranteed, so that the countervoltages 3 induced at small rotary speeds of the brushless, sensorless, direct current motor are located outside of the interference spectrum. Therefore, the zero crossings of the alternating voltages can be reliably detected, and also at small rotary speeds an exact position determination of the rotor of the direct current machine can be provided.

Please amend the paragraph bridging pages 15 and 16 as follows:

With the configuration shown in Figure 4, in addition to the requirements of minimal costs and a minimal place, compensation requirements such as immunity of the demultiplexer of the [comparator] comparator-component arrangement from occurring voltage peaks and other interferences during the not selected time can be satisfied as well. The proposed inventive demultiplexer arrangement is immune both with respect to the operation and also the component specification, so that the voltage drops drifting from one another, such as for example in the demultiplexer arrangement of Figure 2, which can lead to a phase displacement during the operation of the electrical machine are excluded. Furthermore, errors in the phase branches 23 to be evaluated for the voltages 3 due to component tolerances and temperature influences with respect to the amplitude of the produced offset of the phase position, as well as the time course, are excluded. The configuration of demultiplexer which is shown in Figure 4 and associated with each phase branch 23 with a separate [comparator] comparator component [15] 14 additionally produces a low zero signal current. Inputs and outputs are provided with low capacities so that together

with high-ohmic selected source resistances, no relevant phase displacements can occur.

Page 16, first paragraph, amend as follows:

In the configuration of a demultiplexer arrangement illustrated in Figure 4, the used transistor components 17 can be either bipolar transistors or field effect transistors, or also series pass transistors. They are located in each of the phase 23 to be evaluated after the resistor pair 4 or 5. At the input side, the [comparator] comparator components 14 which are controlled through the control voltage input 15 are connected both with the voltage which drops in the reference branch 24, as well as in the corresponding input-side phase branch 23 located at the separate [comparator] comparator component 14, in the brushless, sensorless direct current motor.





